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Conductive Heat Flow In The Randsburg Area, California

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CONDUCTIVE HEAT FLOW IN THE RANDSBURG AREA, CALIFORNIA

by

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This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature.

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INTRODUCTION

The Randsburg known Geothermal Resource Area (KGRA) is located in a tectonically active part of the Mojave Desert just south of the Garlock Fault (Figure 1). To provide background information for geothermal resource appraisal, we have combined the results from five holes drilled for regional heat-flow reconnaissance (USGS, unpublished data) with data from nine additional holes drilled especially as part of this study in an attempt to delineate the conductive thermal anomaly associated with observed geothermal manifestations in the Randsburg area.

The following symbols and units are used frequently in the remainder of this report:

T, temperature °C

Γ, temperature gradient, °C km^{-1} or mKm^{-1}

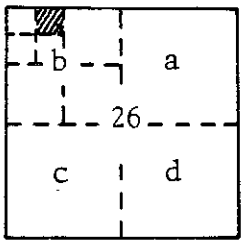
K, thermal conductivity, 1 tcu = 1 mcal $cm^{-1}s^{-1}°C^{-1}$

= 2.39 $Wm^{-1}K^{-1}$

q, heat flow, 1 hfu = 10^{-6} cal $cm^{-2}s^{-1}$

= 41.8 mWm^{-2}

In addition to latitude and longitude, the USGS Water Resources Division convention is used to specify site locations, i.e., 32/38-26bba represents NE 1/4, NW 1/4, NW 1/4, T32N, R38E, sec 26.



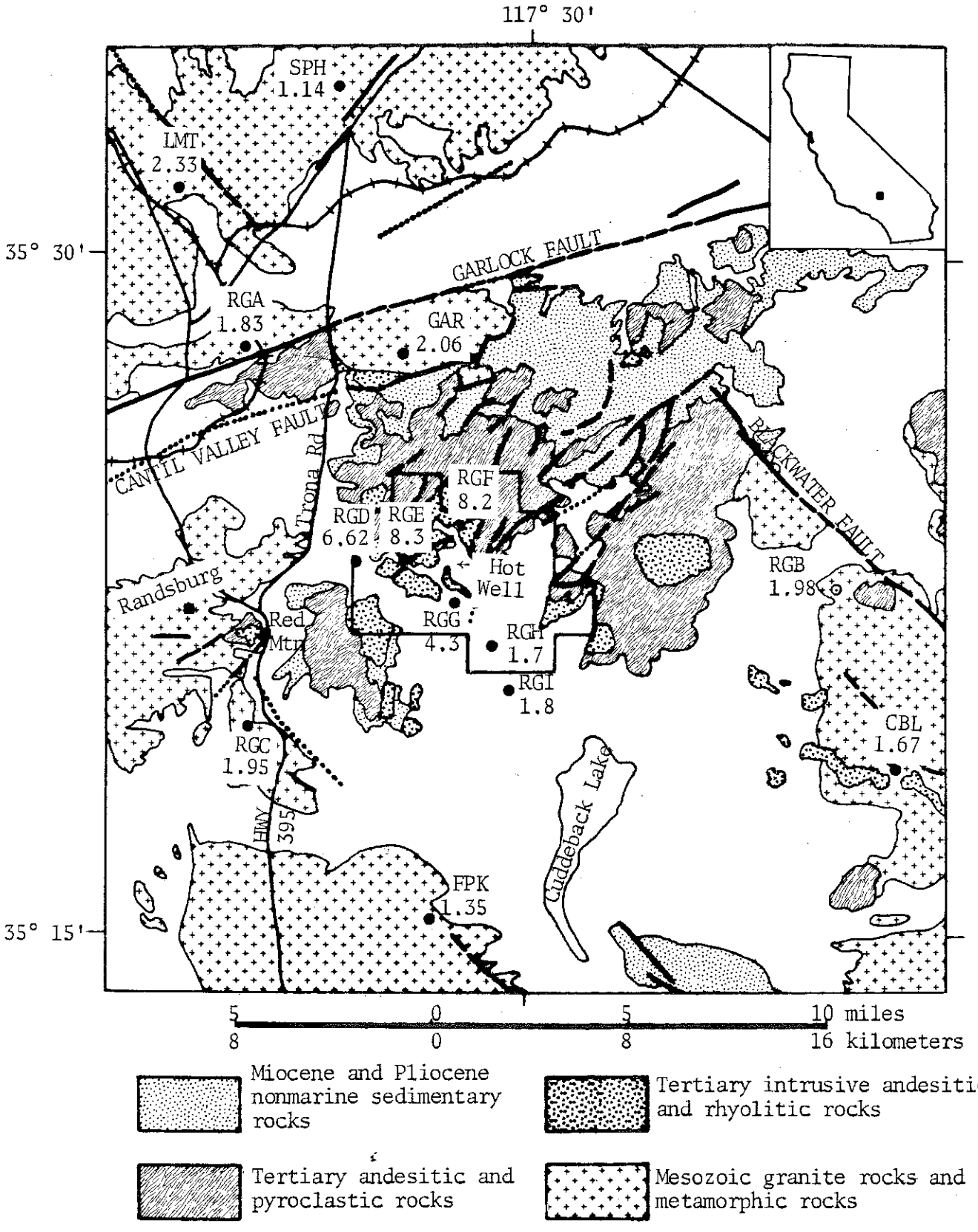


Figure 1a. Geologic sketch map of Randsburg KGRA and environs. KGRA is outlined near center of map. Numbers are heat flows in hfu. (Base map modified from Trona 2° sheet, Jennings and others, 1962.) Inset shows location of Randsburg area.

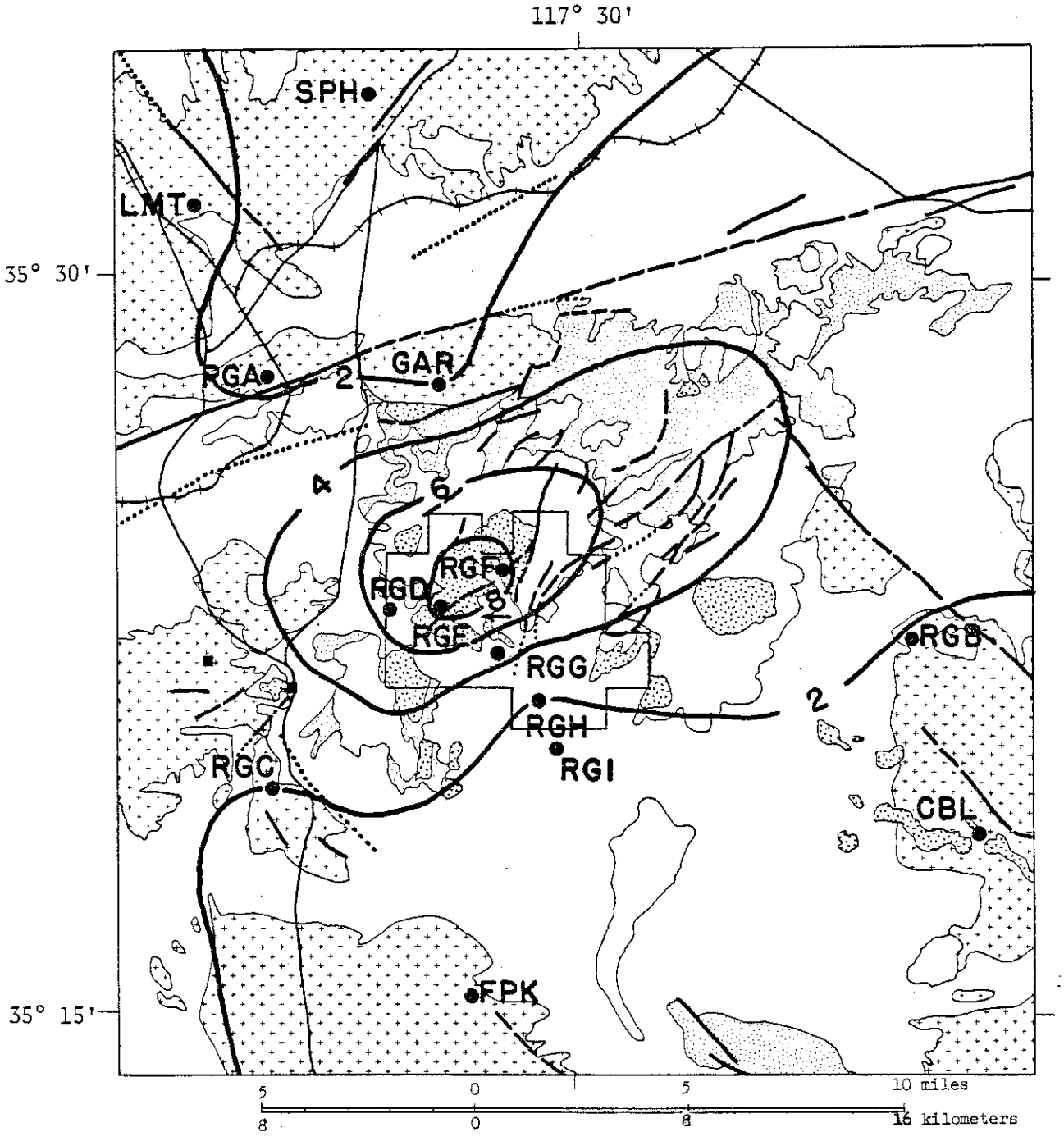


Figure 1b. Heat-flow contours superimposed on the geologic sketch of the Randsburg area. Contour interval, 2 hfu. Arrow shows location of hot well.

SETTING

The Randsburg area forms part of a NNW trending series of hydrothermal convective systems stretching from the Salton Sea area along the eastern margin of the Sierra Nevada as far northward as Susanville, California (Renner and others, 1975; Grim, 1977). It is situated in a complexly faulted highly-mineralized part of the Mojave Block where the NW trending fabric of the Mojave Block converges with the ENE trending Garlock Fault Zone (Figure 1a). The chief geothermal manifestation is a hot well (Figure 1a) whose temperature at 235 m has been reported at 115°C (Table 5 of Renner and others, 1975).

The basement complex in the Randsburg area consists predominantly of late Mesozoic to earliest Tertiary age granitic rocks and lesser Precambrian metamorphic rocks. These rocks are overlain by Tertiary nonmarine sedimentary rocks, andesitic and pyroclastic flows, and hypabyssal rhyolitic and andesitic rocks (Figure 1a).

DRILLING PROGRAM

All but two of the holes (Figure 1a) were drilled using an air compressor and downhole hammer. These air-drilled holes were between 100 and 160 meters deep and a core run was made near the bottom of each hole. The holes in alluvium (RGH and RGI, Figure 1a) were drilled using conventional rotary-mud techniques. It proved impossible to core these gravelly sediments. Ditch samples were collected at 6-meter intervals in all wells. Well completion involved lowering 3.2 cm i.d. (1-1/4") steel pipe to within a meter of bottom, then pumping about 0.7 m^3 of

cement-bentonite grout through the pipe, followed by a wiping plug and clear water. This amount of grout was usually sufficient to seal off the lowermost 30 to 50 meters of the annulus around the pipe in these 15 cm (nominal) diameter holes. An additional ∿3m cement plug was emplaced at the top of the well after the remainder of the annulus had been backfilled with drill cuttings.

DETERMINATIONS OF HEAT FLOW

Details of temperature and thermal conductivity determinations are given in Appendices A and B respectively. Heat flows were calculated by multiplying the least-squares temperature gradient over each linear section of the temperature profiles (Figures 2 through 15) by the appropriate thermal conductivity. For the low porosity rocks (<1%), this was simply the harmonic mean thermal conductivity over the same depth interval. For the higher porosity rocks, this latter value was corrected to reflect the measured or estimated porosity using a geometric mean model (see Sass and others, 1971a). The details of the heat-flow calculations are provided in Table 1, and a summary is given in Table 2 together with lithology and measured (or estimated) porosity. For holes which penetrated non-granitic rocks, detailed lithologic logs are provided in Appendix C.

From the tables and Figure 1a we note a large variation in heat flow both within and outside of the KGRA. Regional background heat flow varies from 1.14 hfu at SPH to 2.33 hfu at LMT only 8 km away (Figure 1a). Measurements of radioactive heat production at all granite sites (USGS, unpublished data) reveal no corresponding variations in heat production of anywhere near a sufficient magnitude to account for the differences in heat flow. Within the area covered by Cenozoic volcanic rocks, conductive heat flows are as high as 8.3 at RGE. A computer-drawn contour map (Figure 1b) suggests a roughly elliptical anomaly aligned parallel to the Garlock Fault and with a maximum greater than 8 hfu somewhere near the hot well. Additional data to the east of the anomaly are required to confirm this tentative interpretation.

Table 1. Principal elements of heat-flow calculations for Randsburg KGRA

Locality	N. Lat.	W. Long.	Elev. m	Depth Range m	N	K (SE)**	Γ (SE)	q (SE)
CBL 30S/43E-23aba	35°18.9'	117°20.2'	1146	46-76	8	6.40 (0.10)	26.05 (0.09)	1.67 (0.03)
LMT 28S/40E-3bdd	35°31.8'	117°39.2'	1012	34-106	23	6.04 (0.07)	37.95 (0.03)	2.33 (0.03)
GAR 28S/41E-35bca	37°27.8'	117°33.4'	1164	46-152	24	7.39 (0.10)	27.90 (0.03)	2.06 (0.03)
SPH 27S/41E-29caa	35°33.6'	117°35.1'	1006	30-101	14	7.14 (0.09)	15.97 (0.01)	1.14 (0.02)
FPK 31S/41E-12bbb	35°15.5'	117°32.3'	936	61-102	9	5.68 (0.15)	23.71 (0.07)	1.35 (0.04)
RGA 28S/40E-25ccc	35°28.0'	117°37.6'	741	85-161	5	6.05 (0.21)	30.26 (0.02)	1.83 (0.06)
RGB 29S/43E-27ccc	35°22.8'	117°21.8'	1015	90-153	7	6.64 (0.14)	29.74 (0.02)	1.98 (0.04)
RGC 30S/41E-18bdc	35°19.6'	117°37.5'	1070	21-160	12	6.69 (0.19)	29.12 (0.04)	1.95 (0.06)
RGD 29S/41E-27bcb	35°23.2'	117°34.5'	1012	26-105	7	5.69 (0.22)	116.1 (0.1)	6.62 (0.25)
RGE 29S/41E-26bcb	35°23.2'	117°33.4'	1021	33-103	5	6.85 (0.4)	120.6 (1.01)	8.3 (0.6)
RGF 29S/41E-24acc	35°23.9'	117°31.8'	1045	53-103	8	6.8 (0.5)	120.0 (0.1)	8.2 (0.6)
RGG 29S/41E-36bad	35°22.4'	117°32.0'	914	30-102	9	4.1 (0.3)	104.5 (0.0)	4.3 (0.3)
RGH 30S/42E-6acb	35°21.4'	117°30.8'	828	24-88	4	4.1 (1.0)	41.8 (1.0)	1.7 (0.4)
RGI 30S/42E-7daa	35°20.3'	117°30.4'	800	36-102	5	4.1 (1.0)	43.6 (0.1)	1.8 (0.4)

** SE represents standard error

Table 2. Summary of lithology, heat flow (q) and porosity for Randsburg KGRA

Site	Rock	Porosity(%)	q(hfu)
CBL	Quartz monzonite	<1	1.67
LMT	Porphyritic granodiorite	<1	2.33
GAR	Quartz monozonite	<1	2.06
SPH	Granodiorite	<1	1.14
FPK	Granodiorite	<1	1.35
RGA	Diorite	<1	1.83
RGB	Quartz monzonite	<1	1.98
RGC	Granodiorite	<1	1.95
RGD	Andesite	<1*	6.62
RGE	Altered rhyolite	4	8.3
RGF	Altered Andesite	2	8.2
RGG	Andesite	5	4.3
RGH	Alluvium	20*	1.7
RGI	Alluvium	20*	1.8

*Estimated quantities as no core or outcrop samples available.

References

Grim, P. J., 1977, Geothermal energy resources of the western United States, Scale 1:2,500,000, National Geophysical and Solar-Terrestrial Data Center, NOAA, Boulder, Colorado.

Jennings, C. W., Burnett, J. L., and Troxel, B. W., 1962, Geologic Map of California, Olaf P. Jenkins Edition, Trona Sheet, Scale 1:250,000, California Division of Mines and Geology, Sacramento.

Renner, J. L., White, D. E., and Williams, D. L., 1975, Hydrothermal convection systems in Assessment of Geothermal Resources of the United States - 1975, edited by D. E. White and D. L. Williams, U.S. Geol. Survey Circ., 726.

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Sass, J. H., Lachenbruch, A. H., Munroe, R. J., Greene, G. W., and Moses, T. H., Jr., 1971b, Heat flow in the western United States: Jour. Geophys. Research, v. 76, p. 6376-6413.

APPENDIX A

Temperature measurements.

Temperatures were obtained at 0.3 m intervals in all wells using the USGS high-resolution continuous logging system. Temperature profiles are presented as graphs in Figures 2 through 15. A smoothed average temperature gradient over 3-meter intervals is also shown on each of these figures. The jerkiness in Figures 2 through 6 was caused by electrical noise in the measurement system which resulted in random excursions of a few hundredths of a degree during logging. In general temperatures are accurate to within a few hundredths of a degree Celsius and temperature differences of a millidegree can be resolved by the system. Apart from the instrumental noise already mentioned, there are few disturbances to the temperature profiles and none that can be attributed readily to convective movement of water in the formation. Thus, in the upper 150 meters in this area, heat flow seems to be exclusively by conduction.

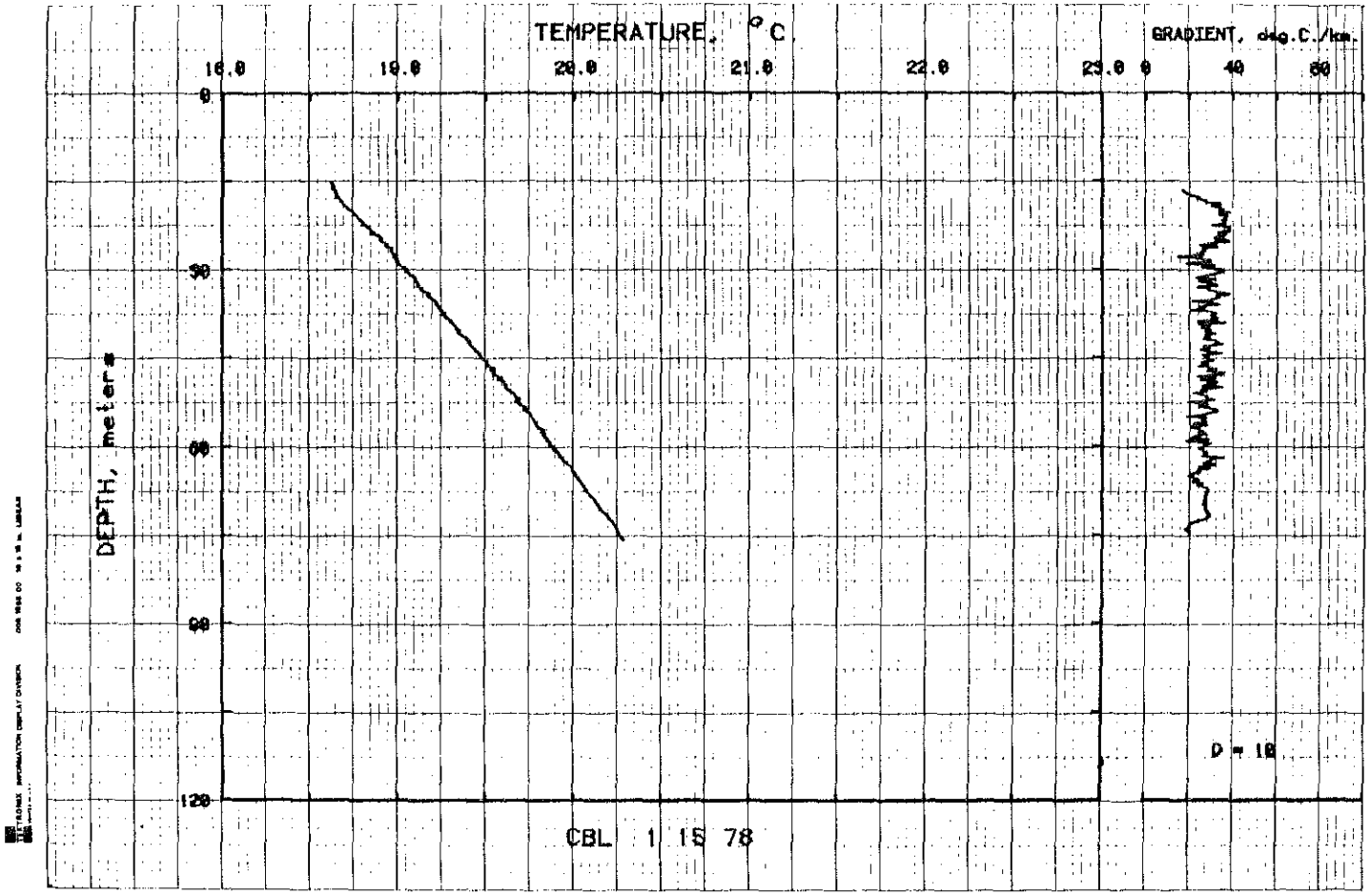

Figure 2. Temperatures and gradients (sliding average over 3 meters) for hole CBL (Cuddeback Lake)

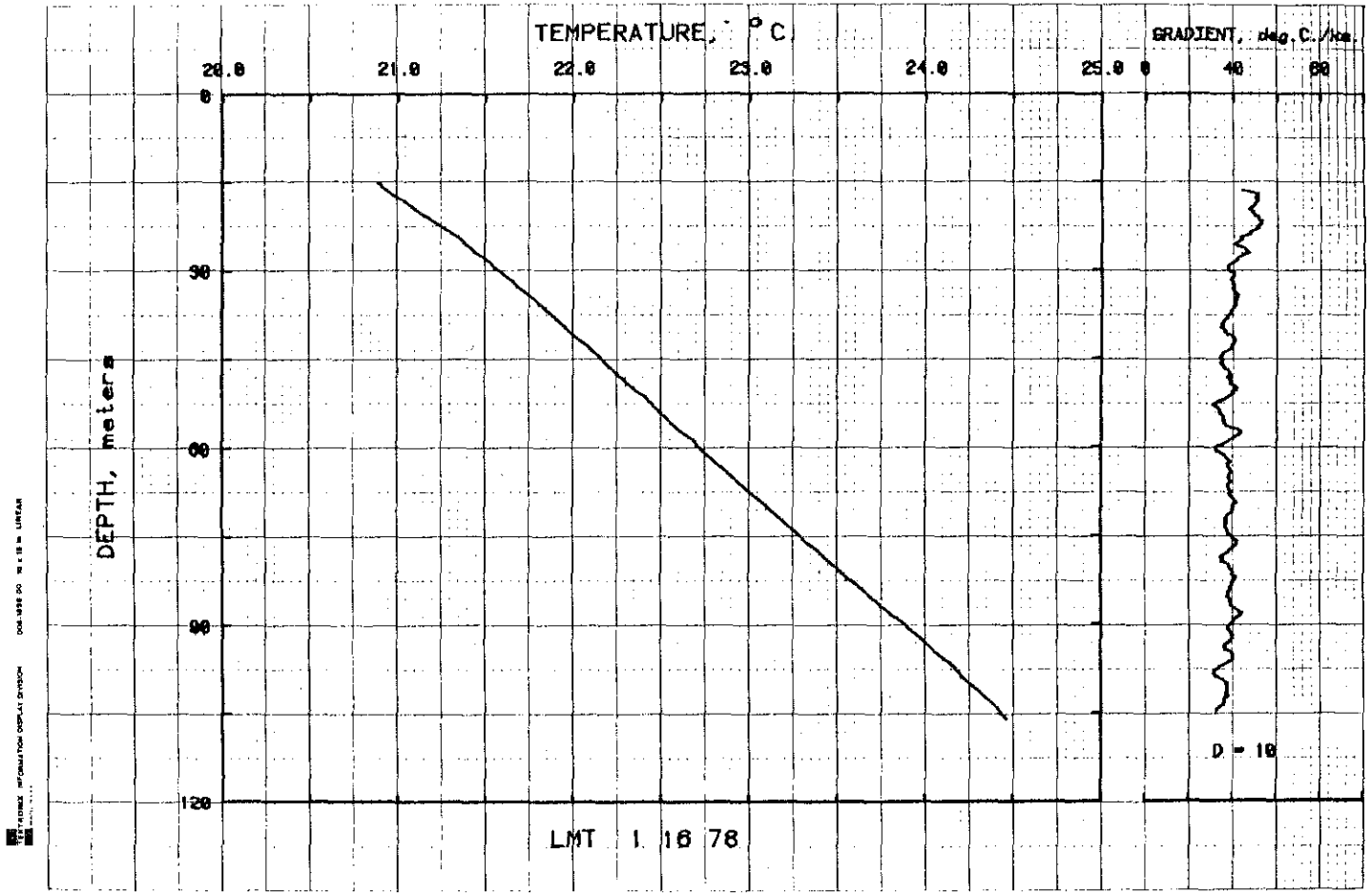

Figure 3. Temperatures and gradients (sliding average over 3 meters) for hole LMT (Laurel Mountain)

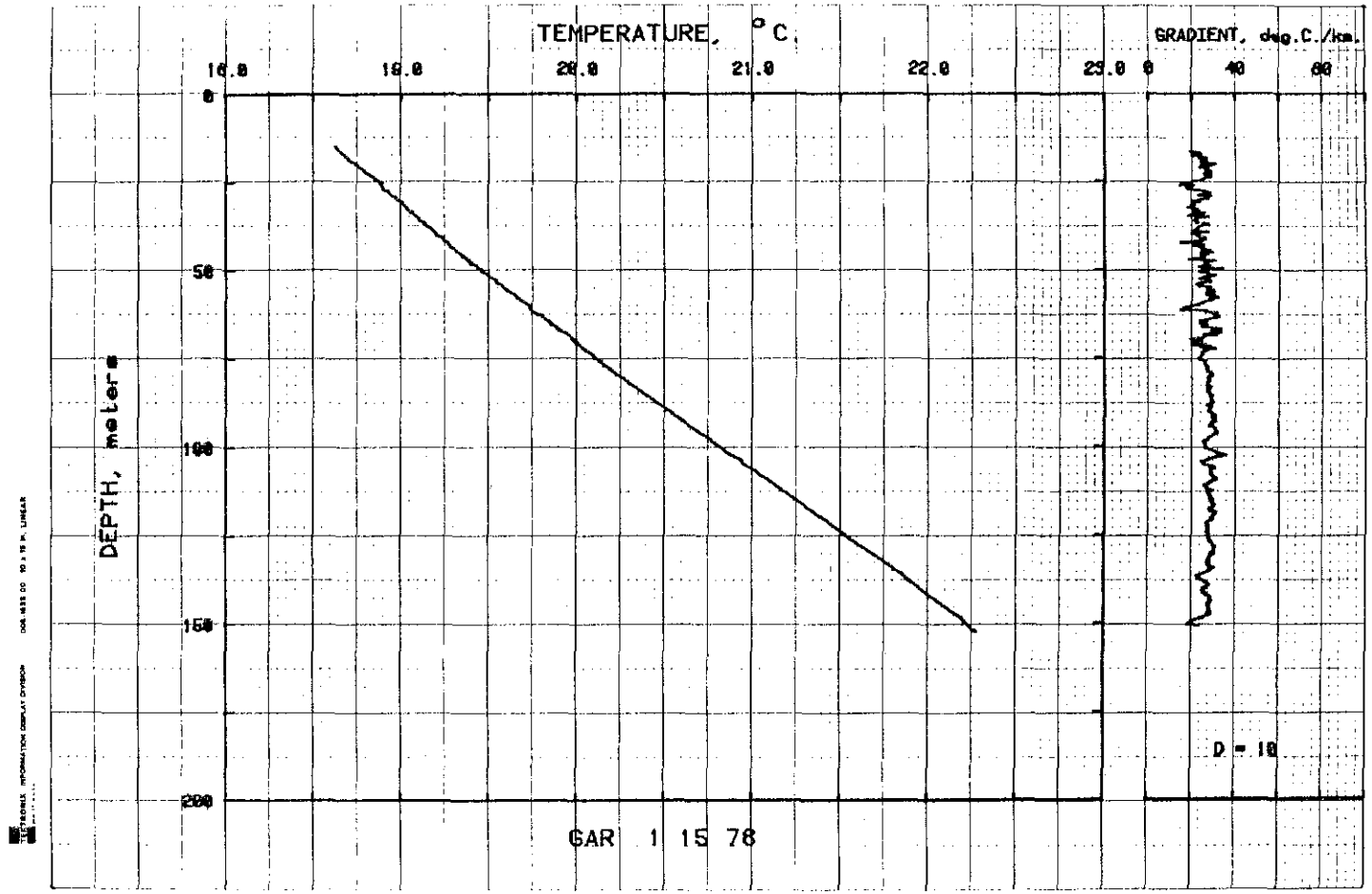

Figure 4. Temperatures and gradients (sliding average over 3 meters) for hole GAR (Garlock)

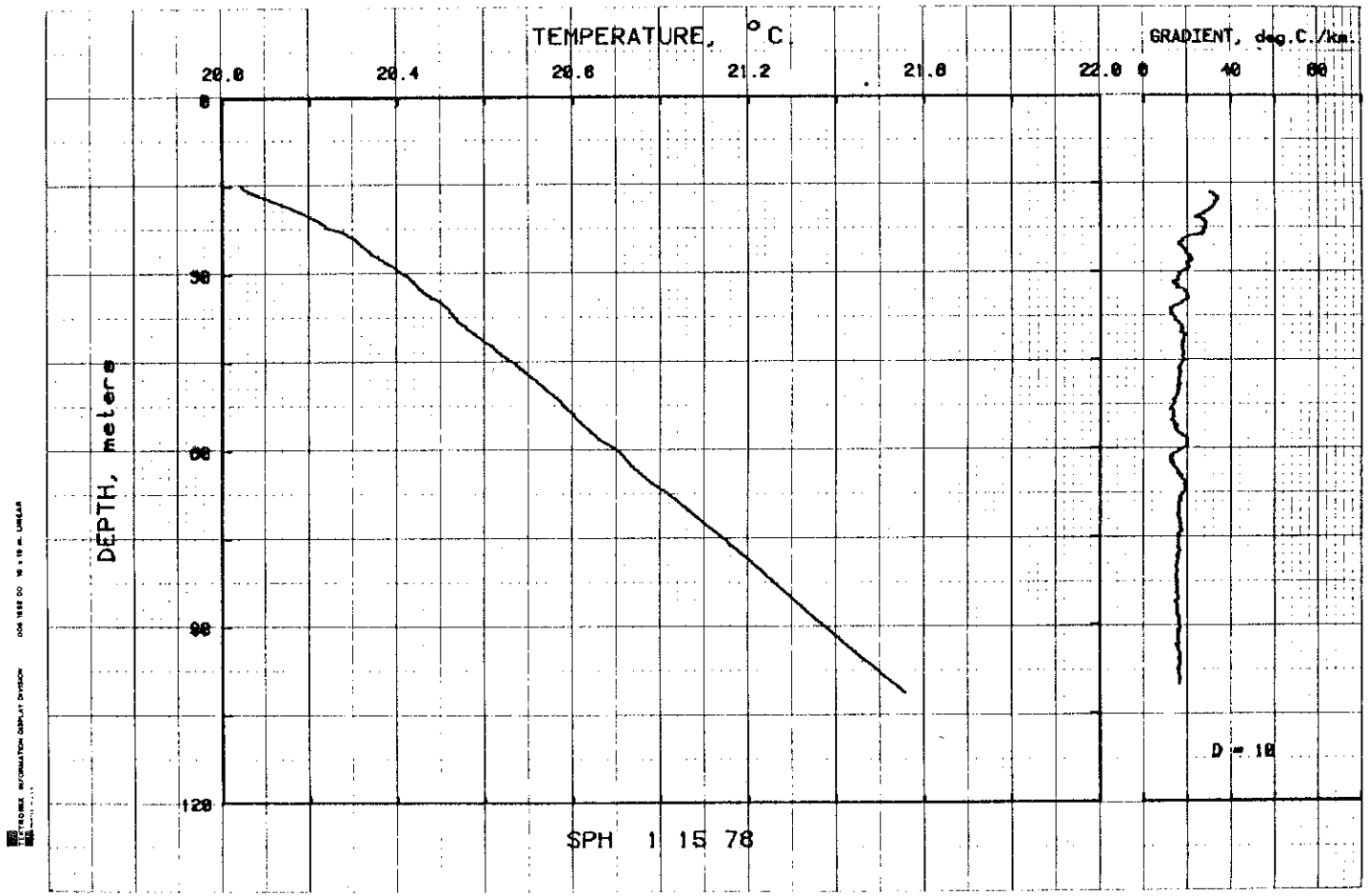

Figure 5. Temperatures and gradients (sliding average over 3 meters) for holes SPH (Spangler Hills)

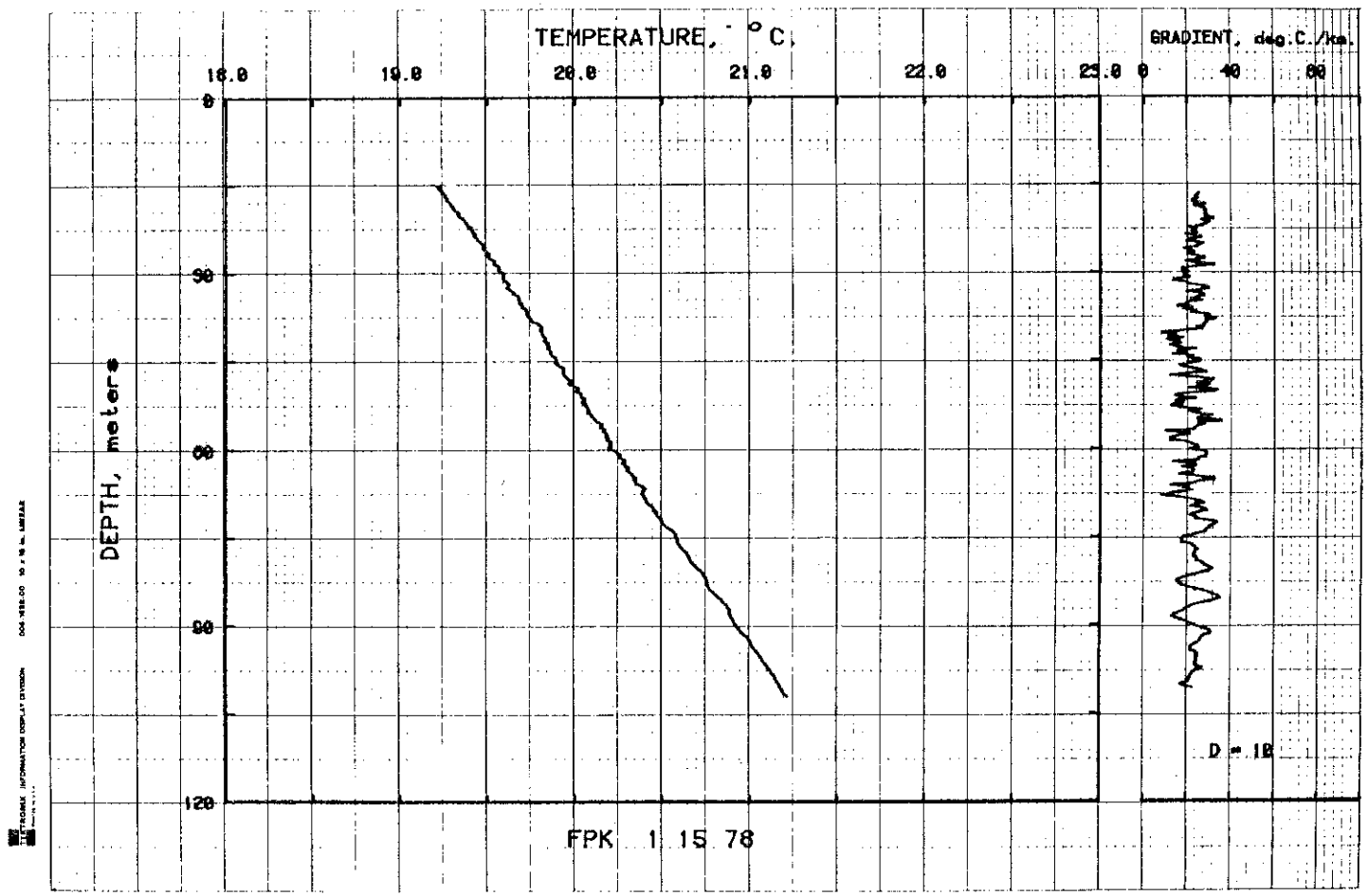

Figure 6. Temperatures and gradients (sliding average over 3 meters) for hole FPK (Fremont Peak)

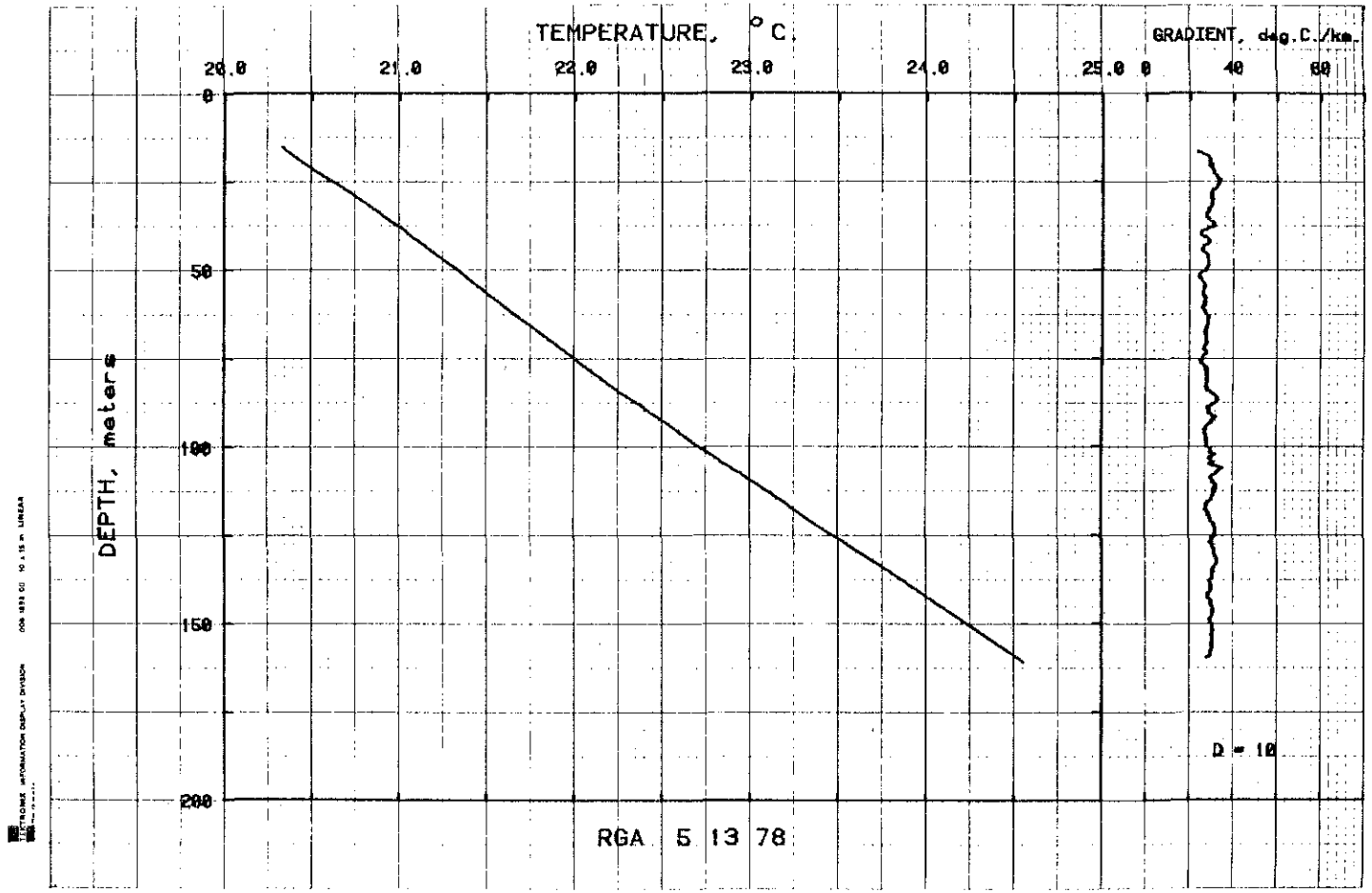

Figure 7. Temperatures and gradients (sliding average over 3 meters) for hole RGA

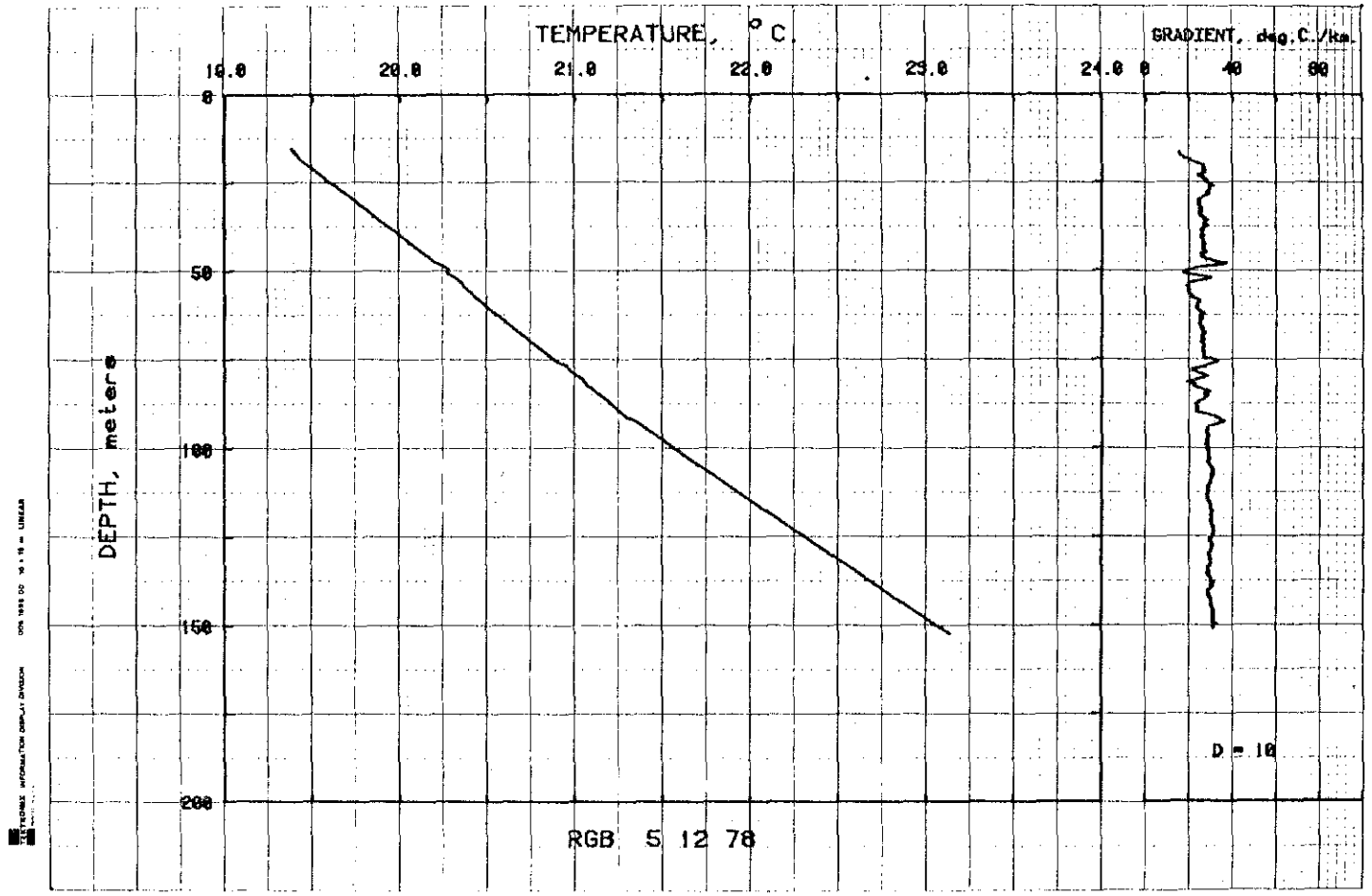

Figure 8. Temperatures and gradients (sliding average over 3 meters) for hole RGB

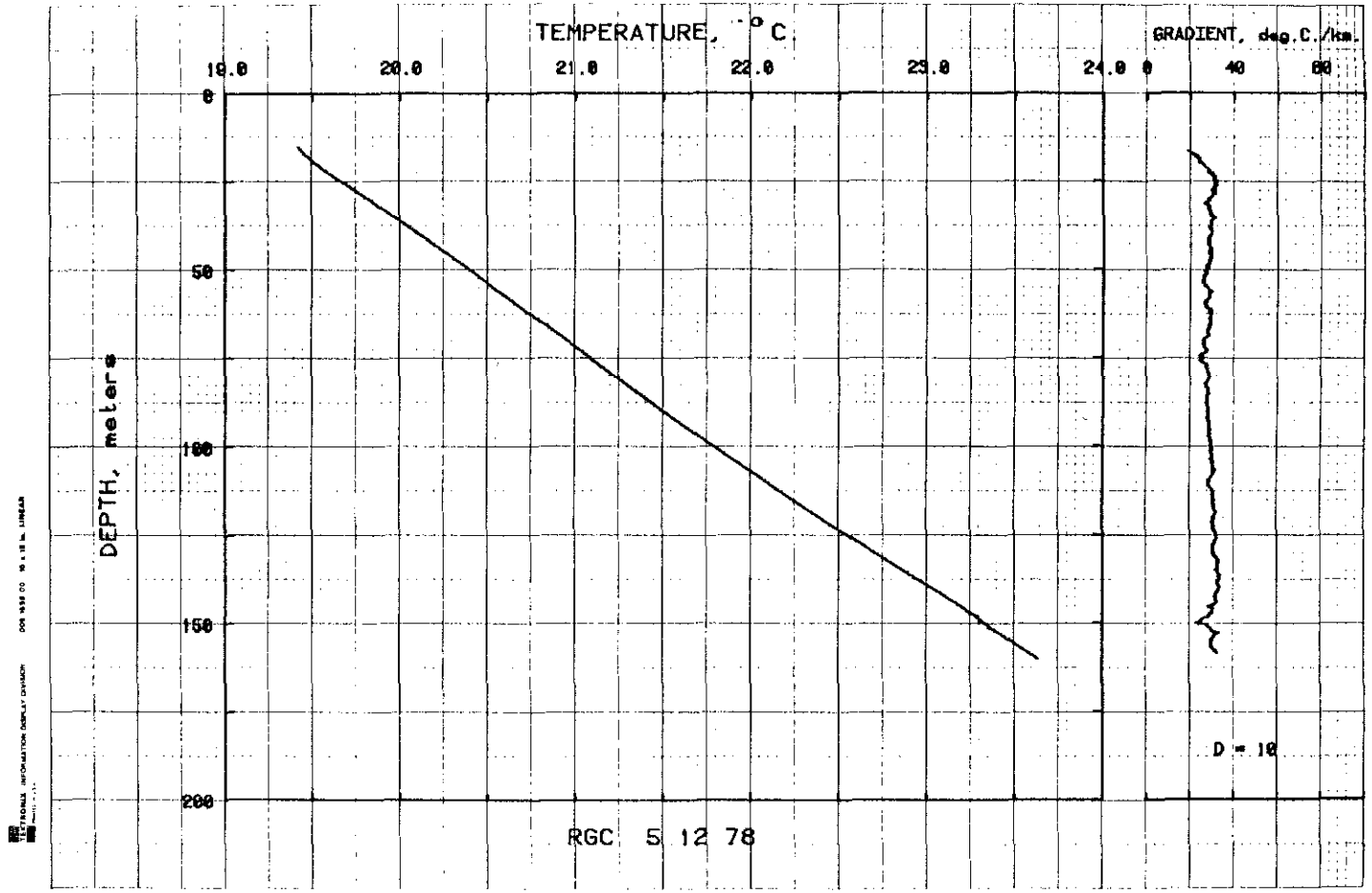

Figure 9. Temperatures and gradients (sliding average over 3 meters) for hole RGC

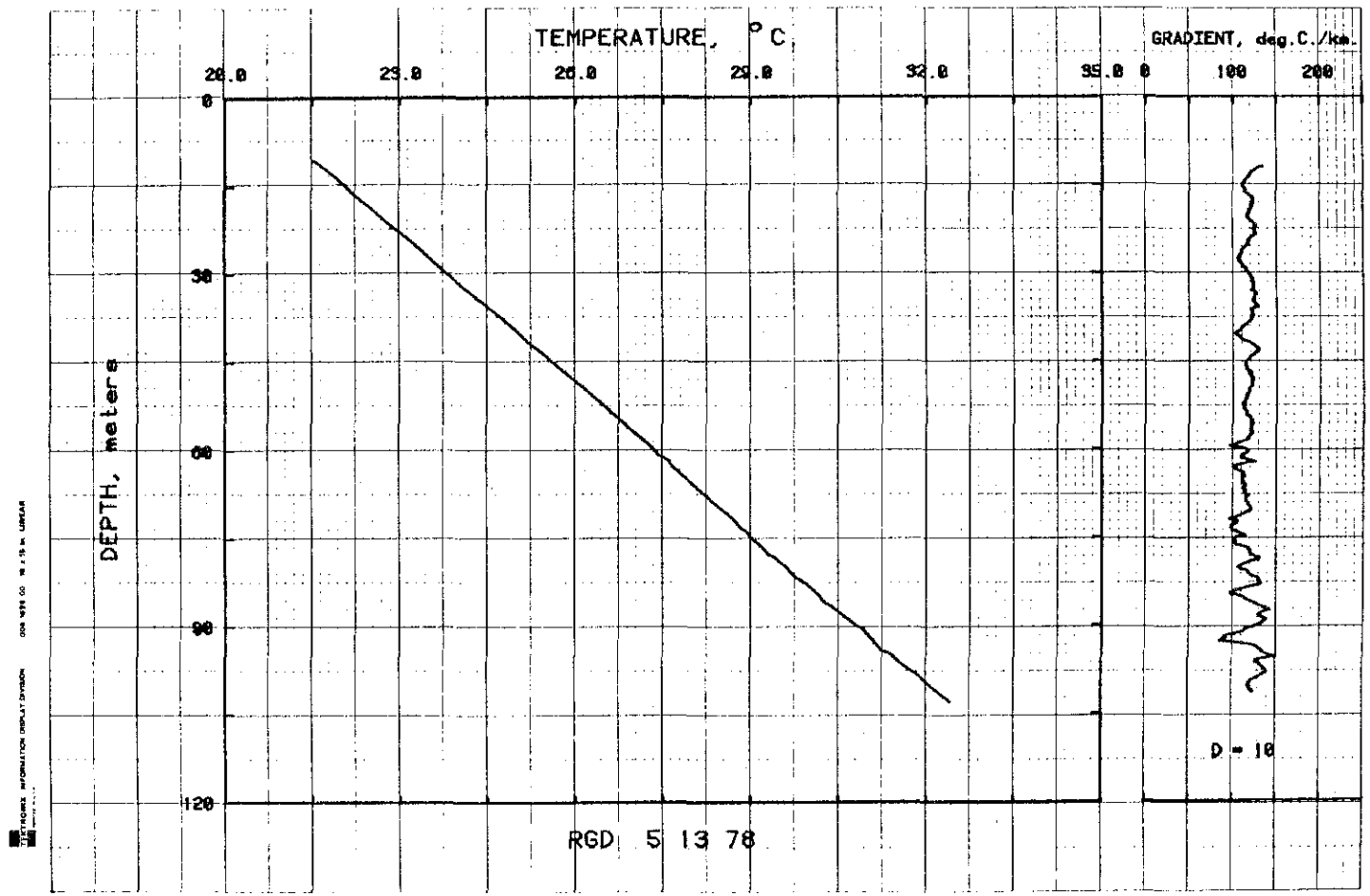

Figure 10. Temperatures and gradients (sliding average over 3 meters) for hole RGD

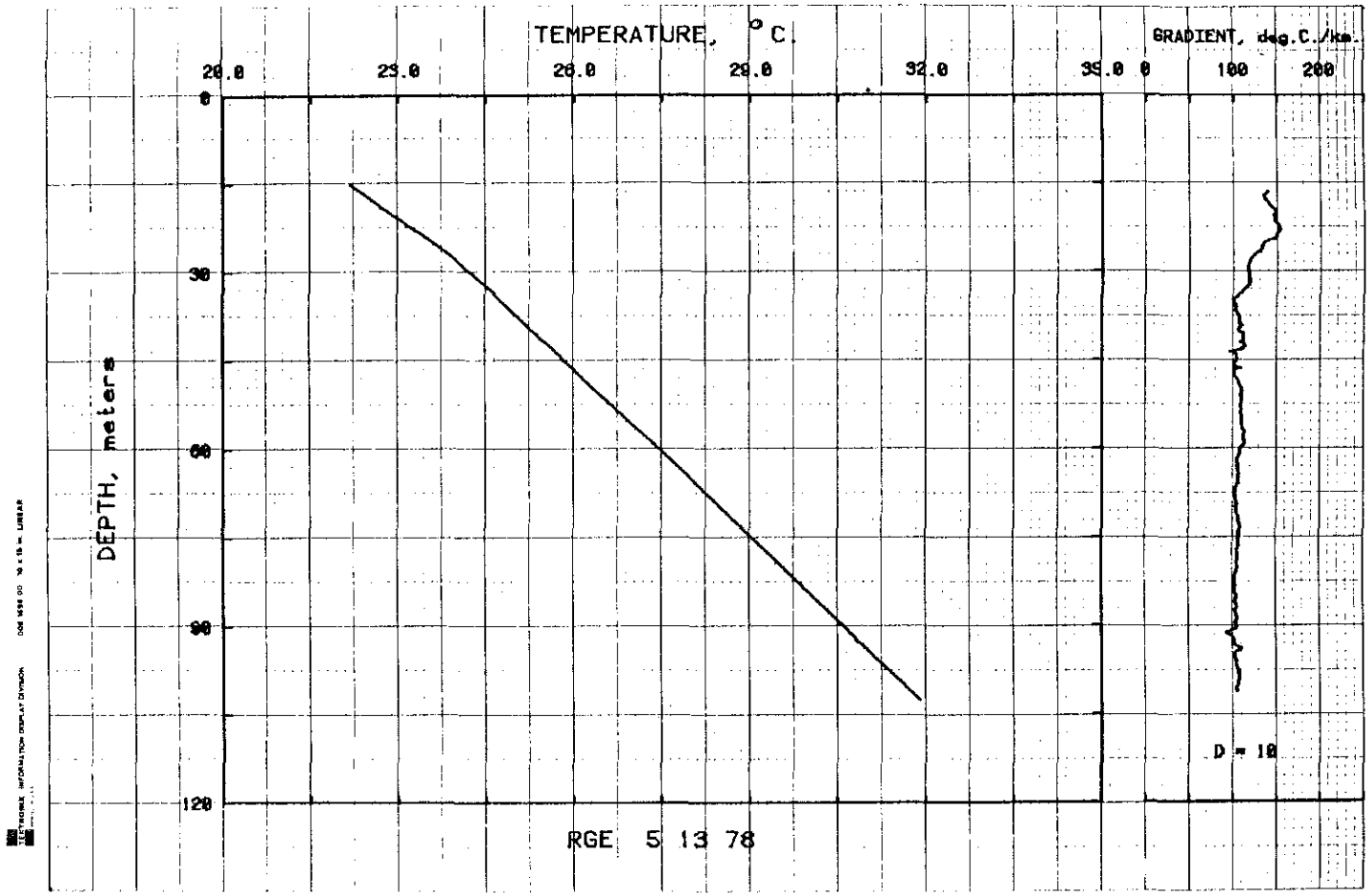

Figure 11. Temperatures and gradients (sliding average over 3 meters) for hole RGE

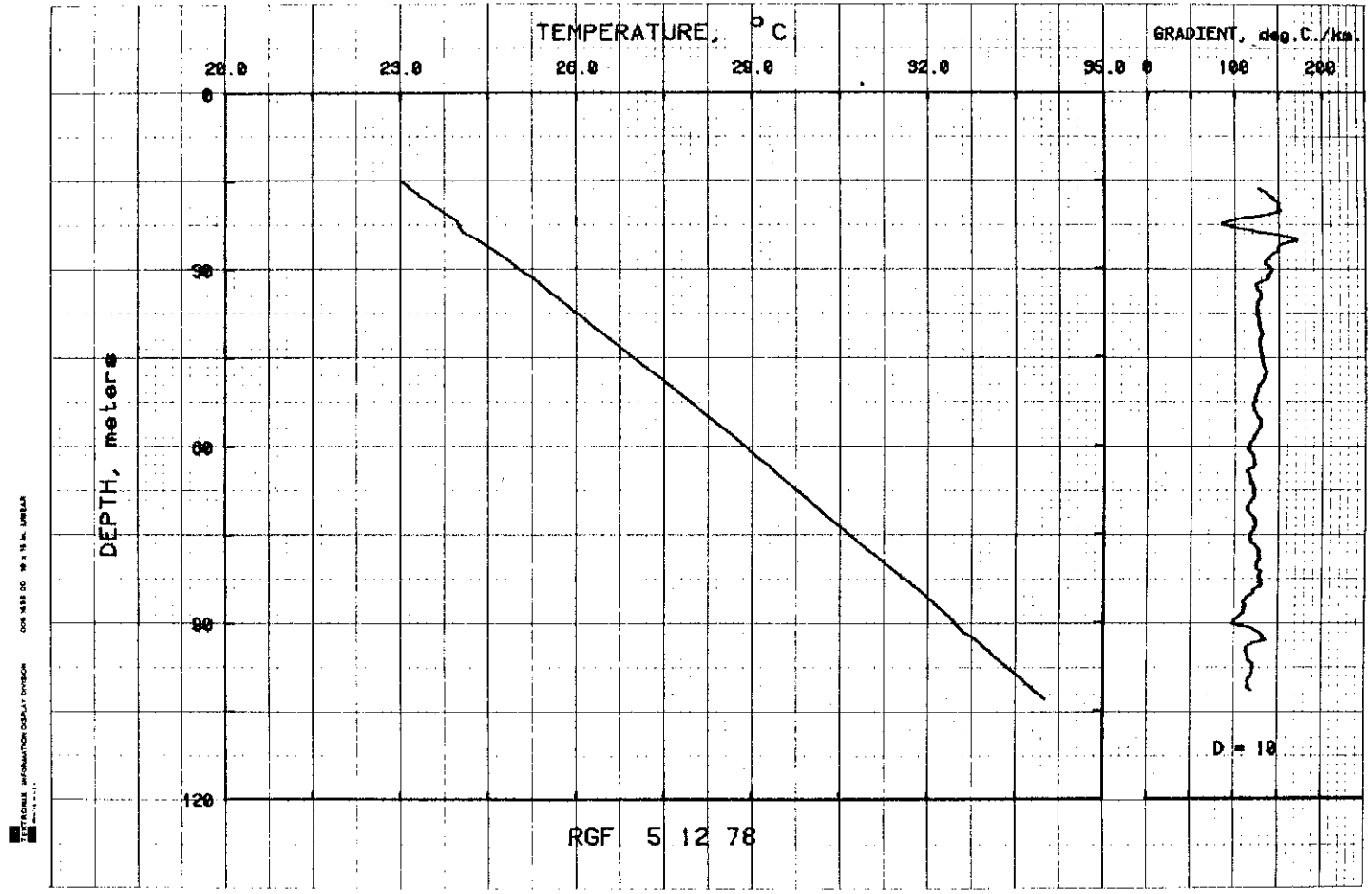

Figure 12. Temperatures and gradients (sliding average over 3 meters) for hole RGF

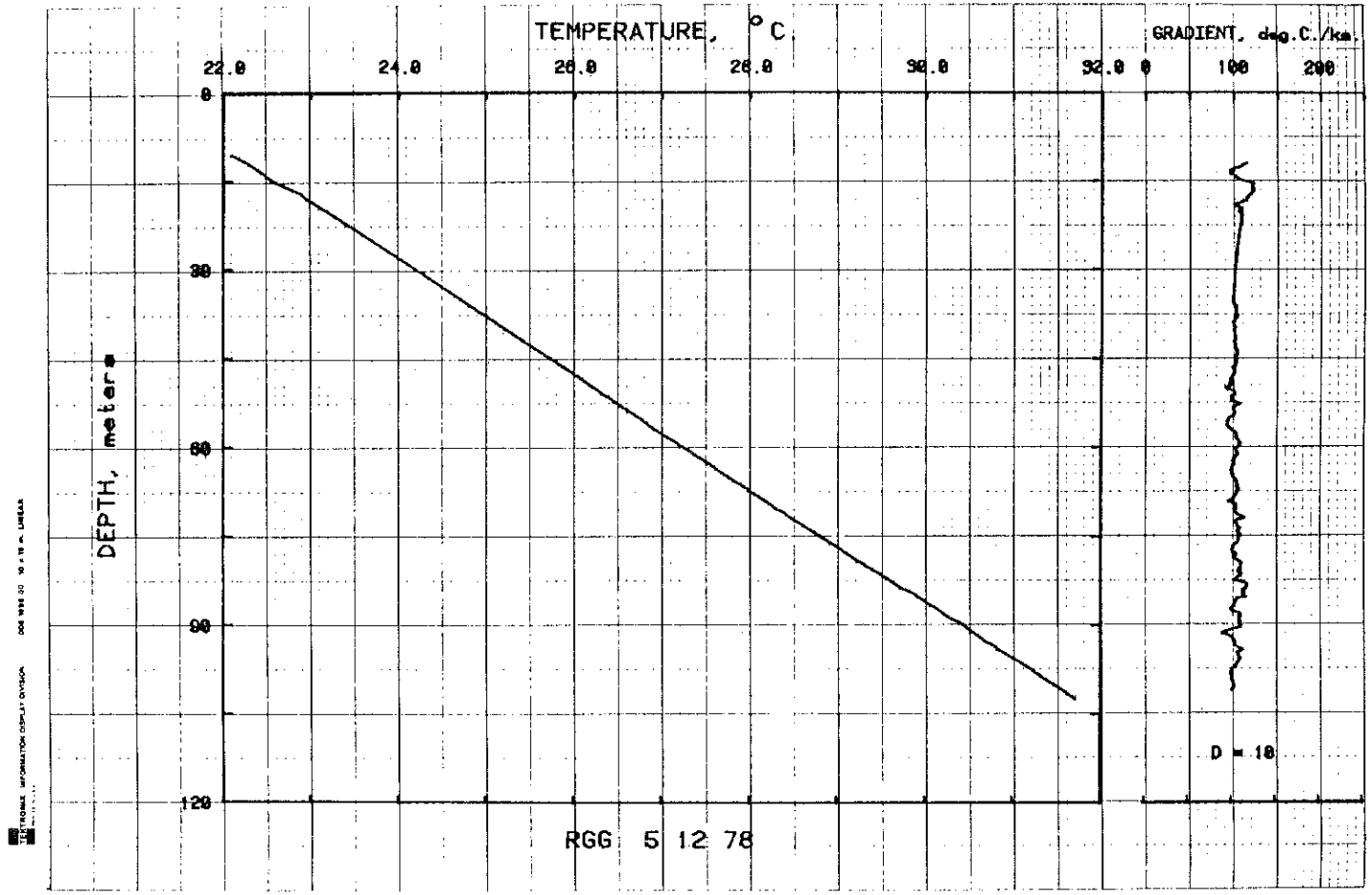

Figure 13. Temperatures and gradients (sliding average over 3 meters) for hole RGG

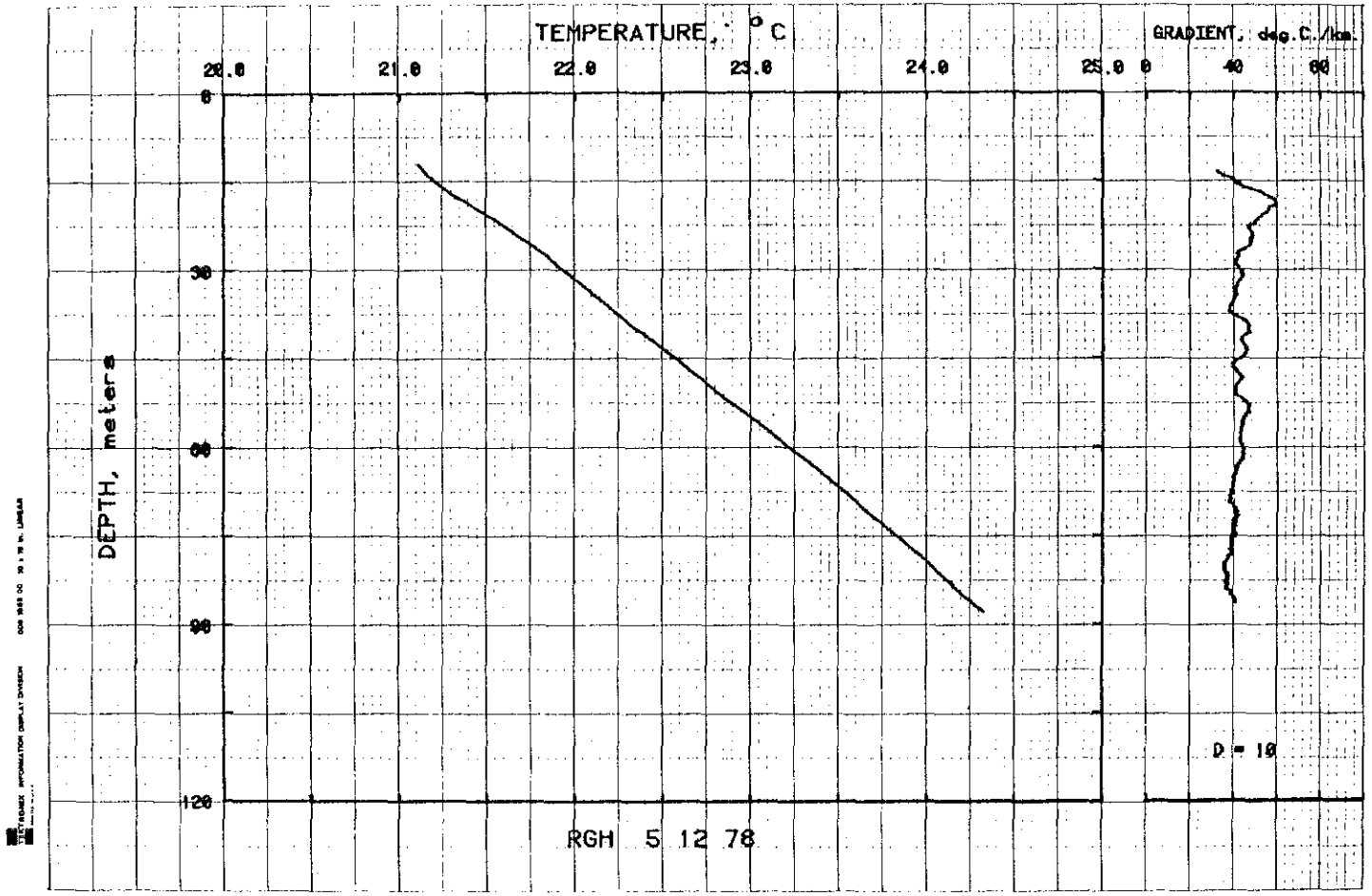

Figure 14. Temperatures and gradients (sliding average over 3 meters) for hole RGH

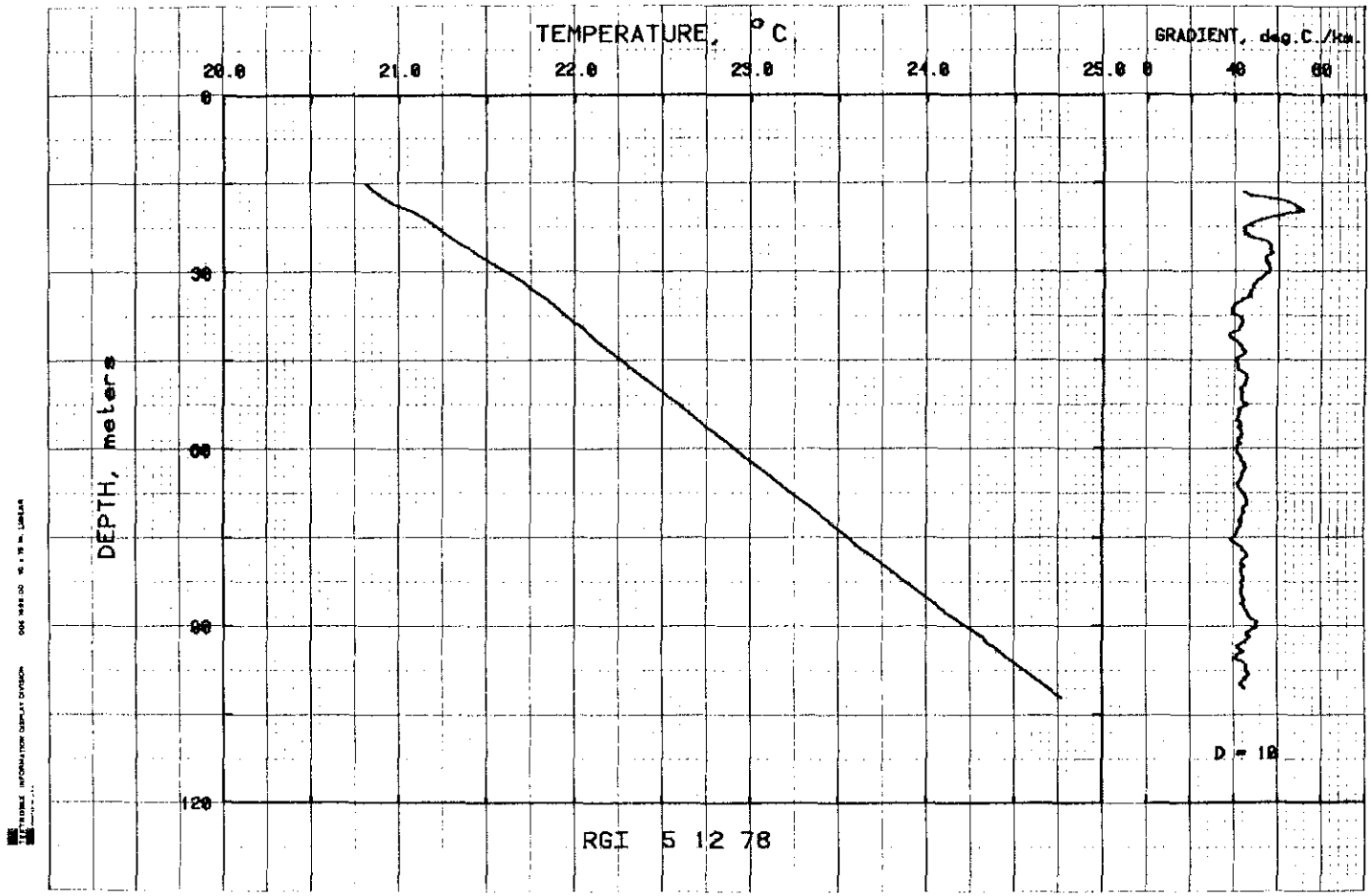

Figure 15. Temperatures and gradients (sliding average over 3 meters) for hole RGI

APPENDIX B

Thermal conductivity data

Tables B-1 through B-14 give measured thermal conductivities of all samples. For outcrop and core samples, solid disks of rock were machined and the conductivities measured in the divided-bar apparatus (see Sass and others 1971b). For these determinations, density and porosity were measured and listed in the tables. All other conductivity measurements were made on drill cuttings using the "Chip" method described by Sass and others 1971a.

Table B-1

Thermal Conductivities for CBL

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm^3	Porosity %
Surface		8.11	3.39	2.57	1.0
0-20	0-6	6.79	2.84		
20-35	6-11	6.21	2.60		
35-50	11-15	6.65	2.78		
50-65	15-20	6.96	2.91		
65-80	20-24	6.81	2.85		
80-95	24-29	6.87	2.88		
95-110	29-34	7.13	2.98		
110-125	34-38	7.29	3.05		
125-140	38-43	6.87	2.88		
140-155	43-47	6.41	2.68		
155-170	47-52	6.19	2.59		
170-185	52-56	6.01	2.52		
185-200	56-61	6.69	2.80		
200-215	61-66	6.28	2.63		
215-230	66-70	6.32	2.65		
230-245	70-75	6.44	2.70		
245-260	75-79	6.98	2.92		

Table B-2

Thermal Conductivities for LMT

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm³	Porosity %
Surface		6.94	2.91	2.67	0.8
0-15	0-5	5.88	2.46		
15-35	5-11	5.99	2.51		
35-50	11-15	6.53	2.73		
50-65	15-20	5.74	2.40		
65-80	20-24	6.32	2.65		
80-95	24-29	5.72	2.39		
95-110	29-34	5.57	2.33		
110-125	34-38	5.86	2.45		
125-140	38-43	5.99	2.51		
140-155	43-47	5.98	2.50		
155-170	47-52	5.86	2.45		
170-185	52-56	6.01	2.52		
185-200	56-61	5.78	2.42		
200-215	61-66	6.54	2.74		
215-230	66-70	6.03	2.52		
230-245	70-75	5.95	2.49		
245-260	75-79	6.13	2.57		
260-275	79-84	5.54	2.32		
275-290	84-88	6.08	2.55		
290-305	88-93	6.12	2.56		
305-320	93-98	6.26	2.62		
320-335	98-102	7.27	3.04		
335-350	102-107	6.29	2.63		

Table B-3

Thermal Conductivities for GAR

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm³	Porosity %
Surface		7.70	3.22	2.61	1.0
0-20	0-6	6.57	2.75		
20-35	6-11	6.70	2.80		
35-50	11-15	7.33	3.07		
50-65	15-20	8.23	3.45		
65-80	20-24	7.45	3.12		
80-95	24-29	7.30	3.06		
95-110	29-34	7.04	2.95		
110-125	34-38	7.42	3.11		
125-140	38-43	7.46	3.12		
140-155	43-47	7.65	3.20		
155-170	47-52	7.37	3.09		
170-185	52-56	6.55	2.74		
185-200	56-61	7.40	3.10		
200-215	61-66	7.71	3.23		
215-230	66-70	7.09	2.97		
230-245	70-75	6.47	2.71		
245-260	75-79	6.78	2.84		
260-275	79-84	7.79	3.26		
275-290	84-88	7.10	3.08		
305-320	93-98	7.60	3.18		
320-335	98-102	7.33	3.07		
335-350	102-107	6.53	2.73		
350-365	107-111	7.77	3.25		
365-380	111-116	7.48	3.13		
380-395	116-120	8.18	3.42		
395-410	120-125	7.67	3.21		
410-425	125-130	7.70	3.22		
425-440	130-134	7.92	3.32		
440-455	134-139	7.68	3.21		
455-470	139-143	7.32	3.06		
470-485	143-148	7.65	3.20		
485-500	148-152	8.01	3.35		

Table B-4

Thermal Conductivities for SPH

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm³	Porosity %
Surface		6.41	2.68	2.54	2.9
0-20	0-6	6.96	2.91		
20-35	6-11	7.04	2.95		
95-110	29-34	7.49	3.14		
110-125	34-38	7.45	3.12		
125-140	38-43	7.45	3.12		
140-155	43-47	7.32	3.06		
155-170	47-52	7.50	3.14		
170-185	52-56	6.89	2.88		
185-200	56-61	6.99	2.93		
200-215	61-66	7.05	2.95		
215-230	66-70	6.54	2.74		
230-245	70-75	6.71	2.81		
245-260	75-79	7.44	3.11		
260-275	79-84	7.28	3.05		
275-290	84-88	6.87	2.88		
290-305	88-93	7.11	2.98		

Table B-5

Thermal Conductivities for FPK

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm³	Porosity %
Surface		5.69	2.38	2.74	1.9
0-20	0-6	6.20	2.60		
25-45	8-14	6.28	2.63		
35-50	11-15	5.58	2.34		
45-65	14-20	6.10	2.55		
50-65	15-20	4.92	2.06		
65-80	20-24	6.05	2.53		
65-85	20-26	5.25	2.20		
80-95	24-29	5.02	2.10		
95-110	29-34	5.54	2.32		
105-107	32-33	6.59	2.76		
110-125	34-38	5.83	2.44		
125.5	38.2	6.25	2.62	2.71	0.5
125.5-128.0	38.2-39.0	5.23	2.19	2.81	0.6
127.0	38.7	6.36	2.66	2.73	0.4
125-140	38-43	5.41	2.26		
140-155	43-47	5.78	2.42		
155-170	47-52	5.70	2.39		
170-185	52-56	5.43	2.27		
185-200	56-61	5.70	2.39		
200-215	61-66	6.37	2.67		
215-230	66-70	6.38	2.67		
230-245	70-75	5.84	2.46		
245-260	75-79	5.67	2.37		
260-275	79-84	5.94	2.49		
275-290	84-88	5.19	2.17		
290-305	88-93	5.13	2.15		
305-320	93-98	5.28	2.21		
320-335	98-102	5.58	2.34		

Table B-6

Thermal Conductivities for RGA

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm³	Porosity %
85-105	26-32	5.12	2.15		
145-165	44-50	5.65	2.37		
185-225	56-68	5.29	2.22		
245-265	75-81	5.85	2.45		
285-305	87-93	6.27	2.62		
325-345	99-105	5.85	2.45		
385-405	117-123	6.83	2.86		
445-465	136-142	5.53	2.32		
496-501	151-153	5.65	2.36		
501-503	153-153	5.87	2.46		
501.5	152.9	5.79	2.42	2.85	0.3
503-508	153-155	6.29	2.64		
508-530	155-162	5.92	2.48		

Table B-7

Thermal Conductivities for RGB

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm^3	Porosity %
85-105	26-32	6.72	2.81		
145-165	44-50	6.43	2.69		
185-205	56-62	5.45	2.28		
245-265	75-81	6.95	2.91		
285-325	87-99	6.56	2.75		
345-365	105-111	6.12	2.56		
385-405	117-123	7.19	3.01		
425-445	130-136	7.17	3.00		
496-501	151-153	6.80	2.85		
501-506	153-154	6.40	2.68		
511-530	156-162	6.37	2.67		

Table B-8

Thermal Conductivities for RGC

Depth range		Conductivity		Density	Porosity
feet	meters	mcal/cm sec°C	W/mK	gm/cm³	%
85-105	26-32	7.29	3.05		
145-165	44-50	7.30	3.06		
185-205	56-62	6.76	2.83		
245-265	75-81	7.03	2.94		
285-305	87-93	6.90	2.89		
345-365	105-111	6.51	2.73		
385-425	117-130	6.54	2.74		
445-465	136-142	5.24	2.19		
496.3	151.3	6.65	2.78	2.73	0.2
498.5	151.9	6.73	2.82	2.71	0.2
499.2	152.2	6.69	2.80	2.72	0.3
500-525	152-160	7.14	2.99		

Table B-9

Thermal Conductivities for RGD

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm³	Porosity %
85-105	26-32	6.03	2.53		
145-165	44-50	5.40	2.26		
185-205	56-62	5.98	2.51		
245-265	75-81	5.89	2.47		
300-302	91-92	6.58	2.76		
306-308	93-94	5.20	2.18		
325-345	99-105	5.00	2.10		

Table B-10

Thermal Conductivities for RGE

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm³	Porosity %
85-105	26-32	7.54	3.16		
145-165	44-50	7.27	3.04		
185-205	56-62	7.06	2.95		
245-265	75-81	7.09	2.97		
299-301	91-92	7.65	3.20		
301-306	92-93	5.58	2.34		
304.1	92.7	8.15	3.41	2.61	2.6
305.7	93.2	6.74	2.82	2.56	5.2
306-308	93-94	7.41	3.10		
325-345	99-105	7.46	3.12		

Table B-11

Thermal Conductivities for RGF

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm^3	Porosity %
85-105	26-32	6.49	2.72		
145-165	44-50	4.62	1.93		
185-205	56-62	6.45	2.70		
245-265	75-81	6.50	2.72		
300-302	91-92	6.79	2.84		
302.8	92.3	8.63	3.61	2.05	1.9
307.5	93.7	8.54	3.58	2.14	2.2
302-307	92-94	6.84	2.86		
307-309	94-94	6.94	2.90		
325-345	99-105	6.22	2.60		

Table B-12

Thermal Conductivities for RGG

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm³	Porosity %
85-105	26-32	4.69	1.96		
145-165	44-50	4.68	1.96		
185-205	56-62	4.49	1.88		
245-265	75-81	4.83	2.02		
299-301	91-92	4.74	1.98		
301-305	92-93	3.93	1.64		
305.1	93.0	4.33	1.81	2.40	5.4
308.7	94.1	4.68	1.96	2.40	5.8
310-312	94-95	4.89	2.05		
325-345	99-105	3.36	1.41		

Table B-13

Thermal Conductivities for RGH

Depth range feet	Depth range meters	Conductivity mcal/cm sec°C	Conductivity W/mK	Density gm/cm³	Porosity %
84-104	26-32	5.01	2.10		
144-164	44-50	5.59	2.34		
184-204	56-62	5.52	2.31		
244-264	74-80	5.29	2.22		
300-320	91-98	5.00	2.09		

Table B-14

Thermal Conductivities for RGI

Depth range		Conductivity		Density	Porosity
feet	meters	mcal/cm sec°C	W/mK	gm/cm³	%
80-100	24-30	5.84	2.45		
140-160	43-49	5.25	2.20		
200-220	61-67	4.44	1.86		
240-260	73-79	5.76	2.41		
300-320	91-98	5.86	2.45		
320-340	98-104	5.47	2.29		

APPENDIX C

Lithologic descriptions

The lithology of the six holes within and nearest the Randsburg KGRA are described in Charts C-1 through C-6. The descriptions are based on examination of the drill cuttings and core (cored intervals are indicated on the charts) with a 10X hand lens.

C-1 **Hole:** RGD **Location:** Randsburg KGRA 40

Started: 2/24/78 **Completed:** 2/24/78 **Drilled by:** Clingan

Notes by: SPG **Scale:** 1" = 50' **Sheet** 1 **of** 1

Depth Feet	Graphic column Core	Rock type	Alteration
0		Weathered light green porphyritic andesite (feldspar phenocrysts to 3mm)	
45'		Clasts of red nonporphyritic to gray andesite, light green rhyolite, and white tuff	
125'		Dark red tuff in various states of alteration to red clay with clasts of altered porphyritic rhyolite and andesite	Intense alteration to white and red clays
145'			
165'		Clasts of light green to gray andesite and rhyolite in gray matrix	
185'		Clasts of light green to gray andesite and rhyolite in red clayey matrix	
225'		Clasts of light green to gray andesite and rhyolite in gray matrix	
245'		Clasts of light green to gray andesite and rhyolite in red clayey matrix	
	302' 306'		
345'			

C-2 **Hole:** RGE **Location:** Randsburg KGRA 41

Started: 2/24/78 **Completed:** 2/25/78 **Drilled by:** Clingan

Notes by: SPG **Scale:** 1" = 50' **Sheet** 1 **of** 1

Depth Feet	Graphic column Core	Rock type	Alteration
0		Weathered tan porphyritic rhyolite	Trace to 5% pyrite (all altered to hematite and/or limonite)
85'		Light gray porphyritic rhyolite (feldspar phenocrysts as large as 3mm)	Partial alteration of feldspar to white clay Trace to 5% pyrite
185'		Light gray porphyritic rhyolite (highly altered)	Nearly complete alteration of feldspars to white clay Trace to 5% pyrite
225'			
265'		Light gray porphyritic to nearly holocrystalline rhyolite (avg. grain size .5 to 3mm)	Partial alteration of feldspars to white clay
301'			~3% pyrite veins calcite
306'			
345'			

C-3 Hole: RGF Location: Randsburg KGRA 42

Started: 2/25/78 Completed: 2/27/78 Drilled by: Clingan

Notes by: SPG Scale: 1" = 50' Sheet 1 of 1

Depth (Ft)	Graphic column	Core	Rock type	Alteration
25'			Weathered tan porphyritic andesite (feldspar phenocrysts to 2 mm in aphanitic groundmass) and light gray porphyritic rhyolite	Trace of pyrite (all altered to hematite and/or limonite)
45'			Reddish gray to gray porphyrite andesite	"
85'			Light gray porphyritic rhyolite	
125'			Reddish gray to dark gray porphyritic andesite minor light gray porphyritic rhyolite (fragments in the andesite)	
185'			Light gray to light green porphyritic rhyolite (feldspar phenocrysts to 6 mm) minor reddish gray andesite	Trace to 3% unaltered pyrite; partial alteration of feldspar to clay
265'			Light green porphyritic rhyolite and reddish gray slightly porphyritic andesite	Mafic phenocrysts in andesite have been altered to chlorite and iron oxides Trace to 3% pyrite
285'			Light green porphyritic rhyolite	Partial alteration of feldspar to clay
300'			Porphyritic rhyolite and porphyritic andesite	
	303' 307'		Porphyritic andesite	Hornblende phenocrysts altered to chlorite and iron oxides. Feldspar altered to clay. 2 to 3% pyrite

C-4 **Hole:** RGG **Location:** Randsburg KGRA

Started: 2/27/78 **Completed:** 2/28/78 **Drilled by:** Clingan

Notes by: SPG **Scale:** 1" = 50' **Sheet** 1 **of** 1

Depth Feet	Graphic column Core	Rock type	Alteration
0		Weathered tan porphyritic andesite	
15'		Brick-red porphyritic andesite (feldspar phenocrysts 6 to 8mm long)	
100'			White felsite with 2% pyrite
145'		Brick-red porphyritic andesite with minor dark gray nonporphyritic andesite	
165'		Brick-red porphyritic andesite	
245'		Dark gray andesite with minor brick-red porphyritic andesite	Trace pyrite
285'			
	301' 310'	Brick-red porphyritic andesite (15% feldspar phenocrysts, 4mm max. length) Minor dark gray andesite	

C-5 **Hole:** RGH **Location:** Randsburg KGRA 44

Started: 2/28/78 **Completed:** 3/1/78 **Drilled by:** Clingan

Notes by: SPG **Scale:** 1" = 50' **Sheet** 1 **of** 1

Depth Feet	Graphic column	Rock type	Gravel Size	Alteration
0		Gravel, silt and clay	Max 45mm avg 10mm	
24'		Gravel, silt and clay	Max 35mm avg 8mm	
44'		Silt, clay and gravel	Max 15mm avg 3mm	
64'		Silt, clay and gravel	Max 20mm avg 3mm	
84'		Gravel, silt and clay	Max 20mm avg 8mm	
124'		Gravel, silt and clay	Max 30mm avg 13mm	
144'		Gravel, silt and clay	Max 30mm avg 12mm	
164'		Gravel, silt and clay	Max 20mm avg 9mm	
184'		Gravel, silt and clay	Max 17mm avg 6mm	
224'		Gravel, silt and clay	Max 25mm avg 9mm	
244'		Gravel, silt and clay	Max 20mm avg 9mm	
264'		Gravel, silt and clay	Max 18mm avg 9mm	
280'		Gravel, silt and clay	Max 15mm avg 9mm	
300'				
320'				

NOTE: Gravel-sized clasts composed of andesite and rhyolite.

C-6 **Hole:** RGI **Location:** Randsburg KGRA 45

Started: 3/1/78 **Completed:** 3/1/78 **Drilled by:** Clingan

Notes by: SPG **Scale:** 1" = 50' **Sheet** 1 **of** 1

Depth Feet	Graphic column	Rock type	Gravel Size	Alteration
0		Gravel, silt and clay	Max 20mm avg 3mm	
20'				
40'				
60'		Gravel, silt and clay	Max 20mm avg 7mm	
80'				
120'		Gravel, silt and clay	Max 15mm avg 4mm	
140'		Silt, clay and gravel	Max 15mm avg 3mm	
160'		Silt, clay and gravel	Max 20mm avg 5mm	
180'				
220'		Gravel	Max 20mm avg 10mm	
240'		Silt, clay and gravel	Max 20mm avg 5mm	
260'		Silt, clay and gravel	Max 20mm avg 3mm	
280'		Silt, clay and gravel	Max 10mm avg 3mm	
320'		Silt, clay and gravel	Max 20mm avg 4mm	

NOTE: Gravel-sized clasts composed of andesite and rhyolite.